International Journal of Agricultural Technology 2016 Vol. 12(7.1):1645-1655
Available online http://www.ijat-aatsea.com
ISSN 1686-9141

Comparison of Catch Sizes and Reproductive Biology of Mud Crab Species of the Genus *Scylla*, Coexisting Populations in the Eastern Gulf of Thailand

S. Koolkalya[1], U. Matchakuea[1] and T. Jutagate[2]

[1]Faculty of Agricultural Technology, Rambhai Barni Rajabhat University, Chanthaburi, Thailand 22000
[2]Faculty of Agriculture, Ubon Ratchathani University, Warin Chamrap, Ubon Ratchathani, Thailand 34190

Koolkalya, S., Matchakuea, U. and Jutagate, T. (2016). Comparison of catch sizes and reproductive biology of mud crab species of the genus *Scylla*, coexisting populations in the Eastern Gulf of Thailand. International Journal of Agricultural Technology 12(7.1):1645-1655.

Edible mud crabs (genus *Scylla*) showed a rapidly increasing demand over time. In the Eastern Gulf of Thailand, there are 3 *Scylla* species were reported and this study aims to understand the fisheries characteristic and life history of individual mud crab species, which occupying in the same area, focusing on catch size and reproductive biology. Comparisons on catch size and reproductive biology among the three species of the genus *Scylla* (*Scylla paramamosain, Scylla olivacea* and *Scylla tranquebarica*) were conducted in Trat Province fishing ground, Eastern Gulf of Thailand. Size spectra of the catch, measured by external carapace width (ECW), ranged from 68 – 155 mm, in which the differences were found both by in terms of species and sexes, so did the weight. All three mud crab species spawn all year round with two peaks *i.e.*, firstly during February-March and secondly during June-November. Average fecundity of *S. paramamosain, S. olivacea* and *S. tranquebarica* was 2,116,514 (±790,649), 1,710,286 (±505,669) and 2,052,305 (±693,208) eggs/crab, respectively. The size at 50% maturity of females *S. paramamosain, S. olivacea* and *S. tranquebarica* were 111.67, 99.35 and 110.97 mm, respectively. The recommended minimum ECW size for female crab is set at 120 mm, to guarantee the sustaining of the resources, is suggested.

Keywords: *Scylla* spp., size spectra, size at 50% maturity, fecundity

Introduction

The mud crabs of the genus *Scylla*, are distributed throughout the Pacific and Indian Oceans, which commonly found in the intertidal zone (Keenan *et al.*, 1998). These carbs are the important commercial coastal aquatic resources, which are high market demand and economic value, due to their sweet and delicious meat (Keenan *et al*., 1998; Imai *et al*., 2004; Waiho *et al*., 2015). The exploitation rate of *Scylla* spp. have been getting higher along time both by the

Coressponding Author: S. Koolkalya**; E-mail address:** sontaya.k@rbru.ac.th

fisheries *per se* as well as the need for the production of soft-shelled crabs and crab aquaculture, which almost totally depend on wild-caught juveniles (Le Vay, 2001; Ikhwanuddin *et al*., 2011; Fielder and Allan, 2004). Although huge amount of utilization, there is little information exists on mud crabs biology and the crabs fisheries (Ikhwanuddin *et al*., 2011). This situation leads to the urgent need on the knowledge on their biological aspects in particular the reproductive biology to guarantee the recruitment in the near future for better management and aquaculture of these resources.

The mud crabs in genus *Scylla* have been taxonomically classified into 4 species *viz.*, *Scylla serrata, Scylla tranquebarica, Scylla olivacea* and *Scylla paramamosain*, which are based on morphometric and genetic characteristics (Keenan *et al*., 1998). In general, the preference habitat of any mud crab species is usually associated with established mangroves, although the suitable environmental condition, in particular the telorance on salinity, may difference from species to species (Le Vay, 2001). This is suggested the needs to understand the biology of the coexisting *Scylla* spp. in the same habitat rather than the approach to individual species of mud crab (Overton and Macintosh, 2002; Hamasaki *et al*., 2011; Ikhwanuddin *et al*., 2011; Ogawa *et al*., 2011).

The Gulf of Thailand (GoT) is one of the important fishing grounds for the mud crabs in genus *Scylla* (Hamasaki *et al*., 2011). The annual catch of mud crabs (mixed species) from the GoT in 2011 was 1,084 metric ton and worth 4,926,567 US$ (Fishery Statistics Analysis and Research Group, 2013). There are 2 important fishing grounds for the mud crabs, *i.e.* the Eastern- and Southern- part of the GoT. From the ecological survey, it is showed that there are 3 *Scylla* species (*S. paramamosain, S. olivacea* and *S. tranquebarica* inhabit in the Eastern part of the GoT (Koolkalya and Matchakuea, 2011), comparable to only 2 species (*S. paramamosain* and *S. olivacea*) that are found in the Southern- part of the GoT, where the comparative study on their biology had been conducted (Overton and Macintosh, 2002; Hamasaki *et al*., 2011). This study, therefore, aims to examine the exploited size ranges of the three species of coexisted populations of the mud crabs in the fishing ground of the Eastern part of the GoT and to ascertain the size at sexual maturity in females of each individual species as well as their fecundity. The result from this study can be used to make a step toward an efficiency management for mud crab resources in this area.

Materials and methods

Three mud crabs species, i.e. *Scylla paramamosain, S. olivacea* and *S. tranquebarica*, were sampled monthly (three days per month, during spring tide; the period of active fishing activity for mud crab in this area) for 12

months from January to December, 2008. All samples were caught by collapsible traps and crab gillnets.The samples were taken both directly from the fishers and from the fish landing sites in Trat Province, Eastern Gulf of Thailand (Fig. 1). Individual sample was taxonomically classified then sexed, weighed (to the nearest 1 g) and measured "External Carapace Width" (ECW) (to the nearest 1 mm). The differences in ECW and weight of each sex of three mud crabs species were test by mean of ANOVA and the Duncan's post test was applied when significant difference was found at $\alpha = 0.05$.

The abdomen shape of the female crabs was classified into maturation stages. The maturity stages were classified according to Islam, 2010, (stage I to stage III), in which stages II and III are regarded as mature. Proportion of the matured females to the total frmales of each size class was used to estimate the size at 50% maturity as

$$P_{\mathrm{ECW}} = \frac{1}{1+\mathrm{e}^{(S_1 - S_2 \mathrm{ECW})}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where; P_{ECW} is the proportion of mature females to total females in each ECW class (10 mm interval), and S_1 and S_2 are the equation coefficients.

The ovaries and testis were removed and weighed (to the nearest 0.1 g) to examine the gonadosomatic index (GSI) in each mud crab species and sex as

$$GSI = \left(\frac{GW}{BW}\right) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where; GW is weight of crab reproductive organ and BW is crab body weight.

Then, the ovaries in stages III and IV were placed into Gilson fluid, shaken vigorously and kept in the dark for 15 days. The individual ovary was, then, washed and the eggs were counted gravimetrically (Bagenal and Braum, 1978). Fecundity was predicted in relation to the ECW as

$$F_{ECW} = cECW^n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where; F_{ECW} is the fecundity in each ECW, and c and n are the equation coefficients.

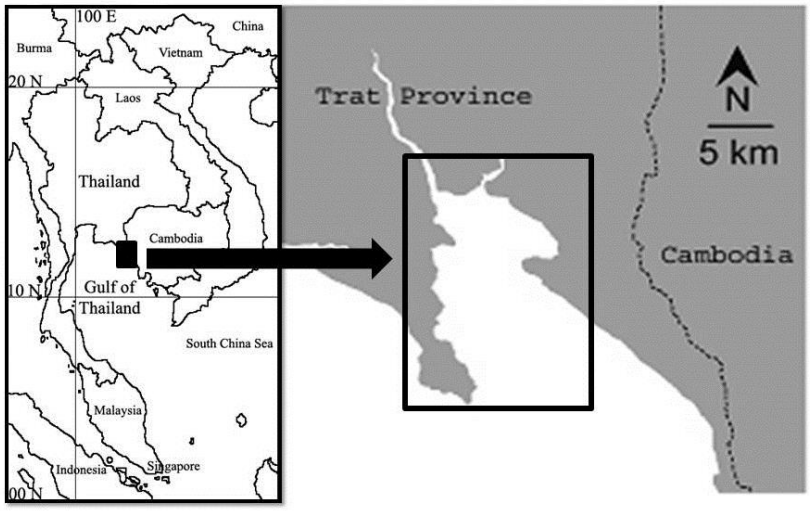

Figure 1 Map and location of the sampling area at Trat Province fishing ground

Results

There were 1,162 individuals mud crabs, from 3 species of the coexisting populations in the Eastern Gulf of Thailand, collected in this study. The size spectra of the catches are showed in Figure 2. The catches of *S. paramamosain* were relatively larger than the other 2 species, which the ECW of males ranged from 80 to 155 mm meanwhile it ranged from 80 to 151 mm for the females. Catches of *S. tranquebarica* showed the wider ECW range of females than males, i.e. from 80 to 143 mm compared to from 68 to 141 mm. The ranges of *S. olivacea* catches were relatively small, which the ECW was ranged from 72 to 116 mm and from 69 to 127 mm for the males and females, respectively. The trends of weight spectra were in similar order as in the size spectra, i.e. the higher- and lower- weight classes were in respective *S. paramamosain* and *S. olivacea*. The ANOVA results showed that ECW and weight of the catches were significantly different ($P<0.05$) both in terms of species and sexes, although the overlaps were found (Duncan's post test, $P<0.05$). The size and weight spectra as well as ANOVA results were summarized in Table 1.

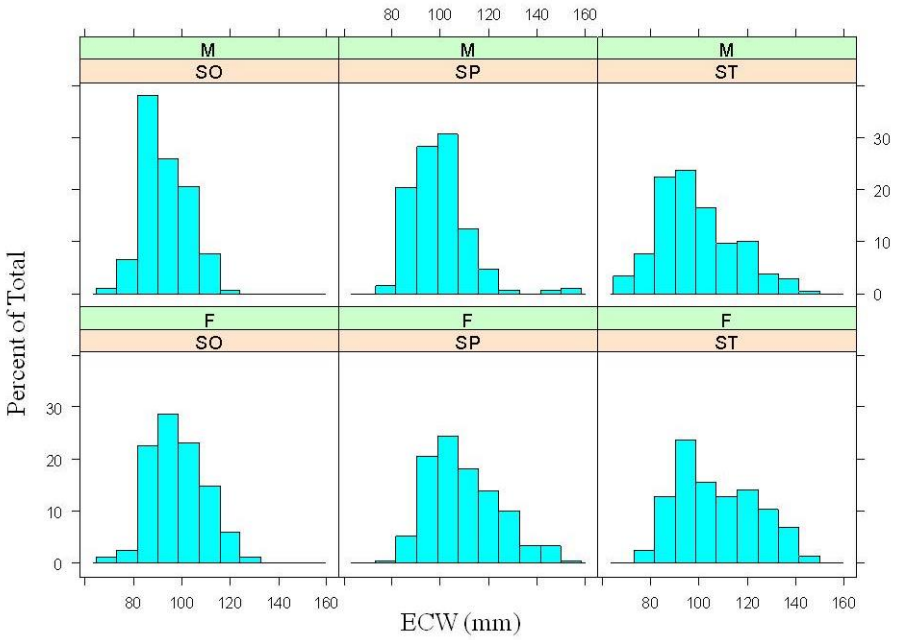

Figure 2 Size distributions of mud crab species, collected from Trat Province between January and December, 2008

Note: SP = *S. paramamosain*, SO = *S. olivacea*, ST = *S. tranquebarica*, M = male, F = female and ECW = External Carapace Width.

The minimum ECW of mature female (i.e. crab which stages III and IV ovaries) *S. paramamosain*, *S. olivacea* and *S. tranquebarica* were 102, 86 and 92 mm, respectively. The relationship between the proportions of mature-to total female crabs in each ECW class were conformed to the logistic function and the size at 50% maturity of each species were 111.67, 99.35 and 110.97 mm for *S. paramamosain*, *S. olivacea* and *S. tranquebarica*, respectively (Fig. 3). Temporal fluctuation in the GSI for each mud crab species was showed in Figure 4. It was observed that GSI of female and male in all species showed synchronized patterns, but slightly different between species. The peaks of GSI were observed twice a year, i.e., during February-March and during June-November. Moreover, it is worthy to note that the relatively high female GSI (> 5) throughout the study period, which implied that all three mud crab species can spawn all year round.

Average fecundity of *S. paramamosain*, *S. olivacea* and *S. tranquebarica* was 2,116,514 (±790,649), 1,710,286 (±505,669) and 2,052,305 (±693,208), respectively. Fecundity in each mud crab species was significantly related to ECW as showed in Figure 5.

Table 1 Size spectra and body weight of mud crab populations in Trat Province.

Species/sex	No. of samples	ECW (mm) Mean±S.D.	Range	Body weight (g) Mean±S.D.	Range
S. paramamosain (male)	192		80-155	197.46±88.71[b]	95-760
S. paramamosain (female)	209	109.47±14.56[a]	80-151	223.25±88.03[a]	90-570
S. olivacea (male)	200	93.27±9.05[c]	72-116	178.32±64.94[c]	80-420
S. olivacea (female)	195	98.38±10.92[b]	69-127	171.03±55.30[c]	50-370
S. tranquebarica (male)	210	98.65±15.35[b]	68-141	202.57±132.81[b]	50-670
S. tranquebarica (female)	156	107.31±16.37[a]	80-143	215.26±94.47[ab]	80-450

Note: The same letter(s) in each column indicates values that are not significantly different when applying the Duncan's post-test, p-valu e > 0.05

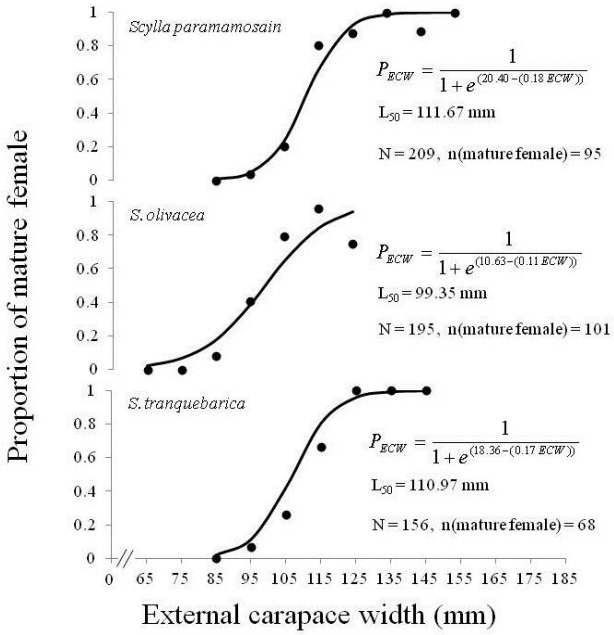

Figure 3 Length at 50% maturity of female mud crab species, coexisting populations in Trat Province fishing ground

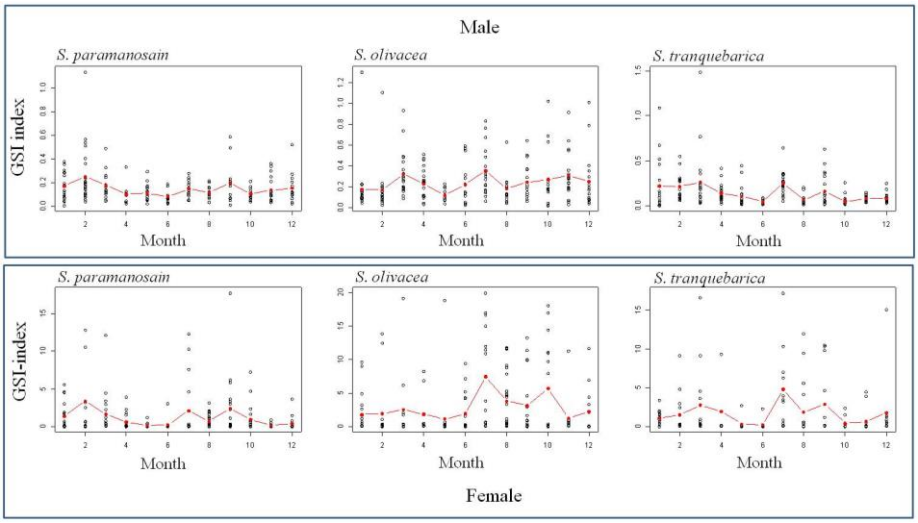

Figure 4 Gonado-somatic index (GSI) of males and females mud crab species.
Note: The line represents the change in mean value of each month.

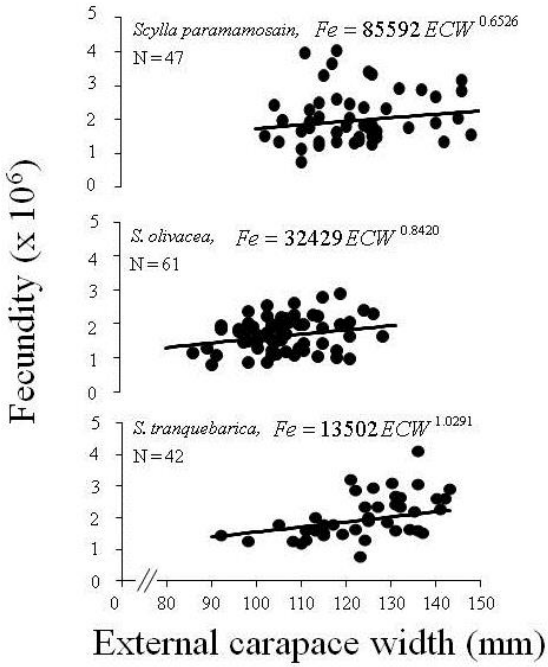

Figure 5 Fecundity of mud crab species, coexisting populations in Trat Province fishing ground

Discussions

The wider size and weight distributions of *S. paramamosain* in Trat Province, the Eastern Gulf of Thailand, followed by *S. tranquebarica* and *S. olivacea*, is conformed to the general distribution pattern of the *Scylla* mud crabs, which *S. paramamosain* is the second largest *Scylla* mud crab after the giant mud crab *Scylla serrata* (Keenan *et al*., 1998). Living in the same area of several species of mud crabs is common (Le Vay, 2001). However, it is always appeared that one species comprise a large percentage of the overall crab population, for example in Aklan, the Philippines, *S. olivacea* comprised 95 percent of the mud crab population, with 2 other species present in the same area (Shelley and Lovatelli, 2011) meanwhile it is *S. paramamosain* that dominant in GoT (Overton and Macintosh, 2002; Hamasaki *et al.* 2011), which agreed to the finding from this study.

The larger females, which were observed in all species, could be caused by the selectivity of the fishing gears. The male *Scylla* is generally larger than female, for example, the weights of males at the carapace width of 150 mm and 200 mm could be heavier than the females at the same carapace width about 55% and 80%, respectively (Shelley and Lovatelli, 2011). However, in this study, the larger size crabs could not enter into the traps because of the size of the entrance that common used in this area limited at 150x270 mm. Moreover, the crab gillnets, another main fishing gear used, were set around the offshore, where the mature females migrate to spawn their eggs, meanwhile the males are quite sedentary (Koolkalaya *et al*., 2006; Waiho *et al*., 2015). Besides, the larger size females in catch structures, found in this study, could be by the female-catches from crab gillnet during their spawning migration (Ogawa *et al*. 2012).

The minimum ECW size at maturity and ECW size at 50% maturity, from the largest to the smallest, were in similar order as *S. paramamosain*, *S. tranquebarica* and *S. olivacea*. The ECW size at 50% maturity at 111.6 mm of *S. paramamosain* is quite closed to the population in Bandon Bay of the Southern-GoT at 112 mm (Hamasaki *et al*. 2011), meanwhile the population of *S. olivacea* in the Andaman Sea attained the ECW size at 50% maturity at 94 mm (Koolkalaya *et al*., 2006), which is relative smaller compare to the finding in this study. No previous information on the maturity of *S. tranquebarica*. However, this mud crab species attain a larger maximum size than *S. olivacea* (Christensen *et al*., 2004) and this could reflect its higher the ECW size at 50% maturity, compare to *S. olivacea*. It is suggested that the difference in size at maturity of the closed relatives, as for the *Scylla* spp. in this study, is the natural process to prevent the hybridization among species (Overton and Macintosh,

2002). However, the much closed ECW size at 50% maturity of these 3 *Scylla* species is implied the potential on natural hybrids, in particular when the populations of any species are low (Overton and Macintosh, 2002; Imai and Takeda, 2005; Ogawa *et al*., 2012)

The GSI results indicated the two peaks during a year for all three *Scylla* species. However, the narrow ranges of GSI, both males and females, implied that these three *Scylla* species can spawn all year round (Le Vay, 2001). In tropical populations, a higher maturation always appears during the wet season with high rainfall, which is consequent in high productivity in coastal waters (Heasman *et al*., 1985; Le Vay, 2001) and this is compatible with the second peak, i.e. during June-November, found in this study. The first peak was during the dry season, which is always the period of re-maturation for the spawned females (Ogawa *et al*., 2012). Average fecundity of *S. paramamosain* was significantly highest and supported the result of the highest abundance *S. paramamosain* in this area (Koolkalya and Matchakuea, 2011). The fecundity of these three *Scylla* species were around 2 million eggs and the large size crabs contained higher eggs. These findings are concurred to the fact that a mature female mud crab produces the eggs ranges from 1 to 6 million and the larger species producing larger numbers of eggs, and larger individuals typically carrying more eggs (Shelley and Lovatelli, 2011).

Base on these findings, although the results showed that each mud crab species, coexisting in Trat Province fishing ground, Eastern Gulf of Thailand had the unique reproductive biology, it is quite difficult to separate minimum legal size species by species. The precautionary minimum ECW size that is allowed to be exploited should be set at between 115 – 120 mm. The minimum legal size of male should be larger than female since female crabs always select a larger size and more aggressive male crab for mating to assure the success in reproduction (Waiko *et al*., 2015). Also for the sustaining of resources, the crab gillnets and other offshore fishing gears should be prohibited during the peak spawning season (i.e. June-November). In addition, further studies on fishing pressures by each fishing gears to the mud crabs and possibility of natural hybridization are among the recommended topics.

Acknowledgement

The authors are grateful to the National Research Council of Thailand for supporting the grant to this study (Grant No. 2551A15102001).

References

Bagenal, TB. and Braum, E. (1978). Eggs and early life history. In: TB., Bagenal (ed.) Methods for Assessment of Fish Production in Freshwaters, 3rd edn. Oxford: Blackwell Scientific Publications: 165–201.

Christensen SM., Macintosh DJ. and Phuong NT. (2004). Pond production of the mud crabs *Scylla paramamosain* (Estampador) and *S. olivacea* (Herbst) in the Mekong Delta, Vietnam, using two different supplementary diets. Aquaculture Research 35: 1013-1024.

Fielder, D. and Allan, G. (2004). Executive summary and recommendations. In: G., Allan and D. Fielder (Eds.), Proceedings of scoping study and workshop, ACIAR working paper, No. 54: 7-9.

Fishery statistics analysis and research group. (2013). The marine fisheries statistics 2011. Department of Fisheries, Thailand.

Hamasaki, K., Matsui, N., and Nogami, M. (2011). Size at sexual maturity and body size composition of mud crabs *Scylla* spp. caught in Don Sak, Bandon Bay, Gulf of Thailand. Fisheries Science 77: 49–57.

Heasman, MP., Fielder, DR. and Shepherd, RK. (1985). Mating and spawning in the mud crab *Scylla serrata* (Forskål). Australian Journal of Marine and Freshwater Research 36: 773-783.

Ikhwanuddin, M., Azmie, G., Juariah, HM., Zakaria, MZ., Ambak, MA. (2011). Biological information and population features of mud crab, genus *Scylla* from mangrove areas of Sarawak, Malaysia. Fisheries Research 108: 299–306.

Imai, H. and Takeda, M. (2005). A natural hybrid mud crab (Decapoda, Portunidae) from Japan. Journal of Crustacean Biology 25: 620–624.

Imai, H., Cheng, JH., Hamasaki, K. and Numachi, K. (2004). Identification of four mud crab species (genus *Scylla*) using ITS-1 and 16S rDNA markers. Aquatic Living Resources 17: 31–34.

Islam, MS., Kodama, K. And Kurokura, H. (2010). Ovarian development of the mud crab *Scylla paramamosain* in a tropical mangrove swamps, Thailand. Journal of Scientific Research 2(2): 380-389.

Keenan, CP., Davie, PJF., Mann, DL., (1998). A revision of the genus *Scylla* De Haan, (1833) (Crustacea: Decapoda: Brachyura: Portunidae). The Raffles Bulletin of Zoology 46(1): 217–245.

Koolkalya, S., Thapanand, T., Tunkijjanujij, S., Havanont, V. and Jutagate T. (2006). Aspects in spawning biology and migration of the mud crab *Scylla olivacea* in the Andaman Sea, Thailand. Fisheries Management and Ecology 13: 391–397.

Koolkalya, S. and Matchakuea, U. (2011). Mud crab resources in Eastern Thailand: Fisheries and socio-economic importance. The proceeding of RGJ seminar series LXXXI Advances in fish ecology study, Ubon Ratchathani University, Thailand, 19th July 2011 .

Le Vay, L. (2001). Ecology and management of mud crab (*Scylla* spp.). Asian Fisheries Science 14: 101–111.

Macnae, W. (1968). A general account of the fauna and flora of mangrove swamps and forests in the Indo-West Pacific region. Advances in Marine Biology 6: 73–270.

Ogawa, CY., Hamasaki, K., Dan, S. and Kitada, S. (2011). Fishery biology of mud crabs *Scylla* spp. at Iriomote Island, Japan: species composition, catch, growth and size at sexual maturity. Fisheries Science 77: 915–927.

Ogawa, CY., Hamasaki, K., Dan S., Obata Y. and Kitada S. (2012). Species composition, reproduction, and body size of mud crabs, *Scylla* spp., caught in Urado bay, Japan. Journal of Crustacean Biology 32(5): 762-768.

Overton, JL., Macintosh DJ. (2002). Estimated size at sexual maturity for female mud crabs (genus *Scylla*) from two sympatric species within the Ban Don Bay, Thailand. Journal of Crustacean Biology 22: 790–797

Shelley, C. and Lovatelli, A. (2011). Mud crab aquaculture – A practical manual. FAO Fisheries and Aquaculture, Technical Paper No. 567. FAO, Rome.

Waiho K., Mustaqim, M., Fazhan, H., Norfaizza, WIW., Megat, FH. and Ikhwanuddin, MHD. (2015). Mating behaviour of the orange mud crab, *Scylla olivacea*: The effect of sex ratio and stocking density on mating success. Aquaculture Reports 2: 50-57.